

**Test Report:  
Total Ionizing Dose Test of OP400**

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## 1. Introduction

The response of the OP400 to ionizing dose radiation was measured after various exposure levels, up to a total dose of 50 krad(Si). Testing was done in August 2006.

## 2. Part Information

The OP400 is a quad low-offset, low-power operational amplifier manufactured by Analog Devices. Being a bipolar part, testing at low dose rate (~20 mrad(Si)/s) was done to check for Enhanced Low Dose Rate Sensitivity (ELDRS). Table I gives the relevant part and test information.

Table 1.  
Part and Test Information

<b>Generic Part Number:</b>	OP400
<b>Manufacturer:</b>	Analog Devices
<b>Lot Date Code (LDC):</b>	0349F
<b>Quantity Tested:</b>	5
<b>Serial No's of Control Sample:</b>	5
<b>Serial No's of Radiation Samples:</b>	1, 2, 3, 4
<b>Part Function:</b>	Quad Low Offset, Low Power Operational Amplifier
<b>Part Technology:</b>	Bipolar
<b>Package Style:</b>	14 lead CERDIP.
<b>Test Equipment:</b>	Parametric Analyzer, dual power supply
<b>Test Engineer:</b>	Forney
<b>Dose Levels (krad (Si))</b>	0, 3.6, 6, 11, 16, 21, 40, 50
<b>Target dose rate (rad (Si)/sec)</b>	20 mrads/s

Fig. 1 shows the pin-out for the OP400.

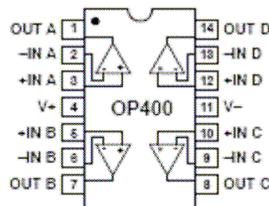


Fig. 1. Pin-out for the OP400

### 3. Conditions During Irradiation

Radiation exposure was done under bias, with the part configured as a voltage follower with  $V_+ = 15V$  and  $V_- = -15V$  (see Figure 2). The outputs were left floating and the inputs were grounded. The part was exposed to gamma radiation in a  $Co^{60}$  cell at NASA-GSFC at a dose rate of approximately 20 mrad(Si)/s.

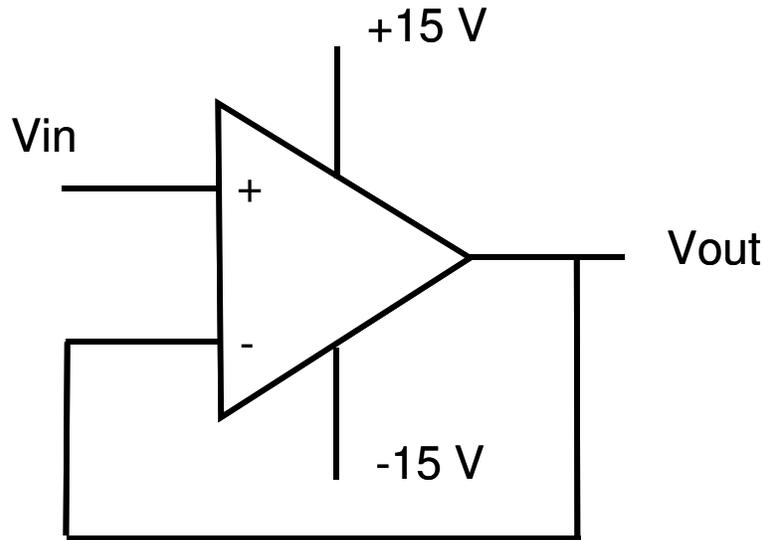


Fig. 2. Bias circuit for the OP400 during exposure to ionizing radiation.

### 4. Part Evaluation

Prior to irradiation, parametric testing and functional testing were performed on the 5 parts using a parametric analyzer. The tests were repeated after each dose up to 50 krad(Si). Only two channels (Channel A and Channel B) were characterized.

### 5. Results

The results of the testing are shown in Tables II - IV.

Table II  
Positive Supply Current as a function of Total Ionizing Dose  
(Specified as 2.9 mA for a total of four Amplifiers)

ISS										
TID	DUT1A	DUT2A	DUT3A	DUT4A	DUT1B	DUT2B	DUT3B	DUT4B	Average	St. Dev.
0	6.75E-04	6.51E-04	6.32E-04	8.91E-04	6.40E-04	6.52E-04	6.10E-04	8.06E-04	6.95E-04	9.94E-05
3.5	6.41E-04	7.11E-04	6.03E-04	8.19E-04	4.29E-13	7.49E-04	5.93E-04	7.42E-04	6.07E-04	2.57E-04
6	6.00E-04	5.96E-04	5.65E-04	8.05E-04	5.72E-04	7.50E-04	5.74E-04	7.41E-04	6.50E-04	9.77E-05
11	5.89E-04	6.05E-04	5.60E-04	8.07E-04	5.68E-04	7.44E-04	5.80E-04	7.47E-04	6.50E-04	9.88E-05
15	5.54E-04	6.25E-04	5.25E-04	7.68E-04	5.44E-04	6.89E-04	7.18E-04	7.19E-04	6.43E-04	9.34E-05
21	5.36E-04	5.87E-04	5.42E-04	7.25E-04	5.14E-04	6.60E-04	5.96E-04	6.68E-04	6.04E-04	7.44E-05
40	4.82E-04	5.34E-04	4.84E-04	6.48E-04	6.37E-04	5.95E-04	6.44E-04	6.11E-04	5.79E-04	6.98E-05
50	4.52E-04	5.03E-04	4.73E-04	6.80E-04	4.41E-04	5.68E-04	6.28E-04	5.69E-04	5.39E-04	8.65E-05

Table III  
Positive Input Bias Current as a function of Total Ionizing Dose  
(Specified as 3 nA per channel)

lin(+)										
TID	DUT1A	DUT2A	DUT3A	DUT4A	DUT1B	DUT2B	DUT3B	DUT4B	Average	St. Dev.
0	4.99E-10	6.07E-10	5.86E-10	4.36E-10	4.84E-10	4.81E-10	5.42E-10	4.87E-10	5.15E-10	5.81E-11
3.5	1.66E-09	1.66E-09	1.74E-09	1.52E-09	7.30E-10	1.50E-09	1.54E-09	1.47E-09	1.48E-09	3.16E-10
6	3.09E-09	2.93E-09	3.12E-09	2.84E-09	2.83E-09	2.75E-09	2.79E-09	2.69E-09	2.88E-09	1.56E-10
11	5.25E-09	4.89E-09	5.05E-09	4.81E-09	4.82E-09	4.44E-09	4.68E-09	4.36E-09	4.79E-09	2.95E-10
16	9.83E-09	9.20E-09	9.33E-09	9.08E-09	9.25E-09	8.26E-09	8.70E-09	8.14E-09	8.97E-09	5.71E-10
21	1.24E-08	1.15E-08	1.18E-08	1.14E-08	1.15E-08	1.04E-08	1.09E-08	1.03E-08	1.13E-08	7.09E-10
40	2.19E-08	2.03E-08	2.05E-08	2.05E-08	2.06E-08	1.85E-08	1.94E-08	1.86E-08	2.00E-08	1.14E-09
50	2.78E-08	2.58E-08	2.59E-08	2.60E-08	2.61E-08	2.38E-08	2.46E-08	2.36E-08	2.55E-08	1.39E-09

Table IV  
Input Offset Voltage as a Function of Total Ionizing Dose  
(Specified as 1.5E-04)

Voffset								
TID	DUT1A	DUT2A	DUT3A	DUT4A	DUT1B	DUT2B	DUT3B	DUT4B
0	3.62E-05	-2.25E-05	2.78E-05	-7.00E-05	3.84E-07	-6.35E-05	-3.83E-05	-7.35E-05
3.5	4.62E-06	-5.89E-05	-3.66E-06	-1.06E-04	-2.86E-05	-8.94E-05	-6.22E-05	-9.94E-05
6	8.45E-06	-4.55E-05	9.41E-06	-9.61E-05	-2.03E-05	-9.51E-05	-5.28E-05	-9.46E-05
11	1.34E-05	-4.68E-05	8.27E-06	-8.54E-05	-2.38E-05	-8.92E-05	-5.46E-05	-9.90E-05
16	1.69E-05	-2.72E-05	3.50E-05	-7.70E-05	-2.33E-05	-1.05E-04	-5.27E-05	-1.09E-04
21	9.30E-06	-2.85E-05	3.12E-05	-8.17E-05	-3.34E-05	-1.11E-04	-4.87E-05	-1.04E-04
40	4.10E-05	3.85E-06	6.57E-05	-5.32E-05	-2.49E-05	-1.04E-04	-4.02E-05	-9.23E-05
50	2.61E-05	-1.10E-05	6.24E-05	-5.41E-05	-3.04E-05	-1.20E-04	-4.78E-05	-1.09E-04

## 6. Conclusions

The bias current and input offset voltage remained within specifications up to 50 krad(Si). The input bias current went out of specification between 6 and 11 krad(Si).